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Preliminary Canopy Structure Estimates For The Forest Site Of The Program WIND Study

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Preliminary Canopy Structure Estimates For The Forest Site Of The Program WIND Study

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Foreword

Program WIND is a cooperative applied research program between the USDA Forest Service and the U.S. Army Atmospheric Sciences Laboratory, White Sands Missile Range, New Mexico. The object of Program WIND is to evaluate meteorological and dispersion models.

These data were collected during the summer of 1985 in support of Program WIND and funded by the USDA Forest Service, Forest Pest Management Staff, Washington Office and the Pacific Forest and Range Experiment Station, Forest Fire Laboratory, Riverside, CA. Questions should be directed to Dr. James Bergen, Riverside, CA (714)351-6565 or John W. Barry, Program Manager, Davis, CA (916)758-4600.

Abstract

A preliminary survey of two plots located at the tower positions of the forest site for Program WIND shows an apparent decrease in Leaf Area Index from the stand edge to the central tower. Data for diameter at breast height, tree height, height to live crown, species, and canopy cover are presented together with a derived estimate of the vertical distribution of foliage.

INTRODUCTION

This memorandum is intended primarily as an aid to planning field projects to be executed in conjunction with Program WIND and in the preliminary interpretation of the elements of the very large WIND data base as they emerge after the completion of the scheduled field program. Timeliness is, therefore, somewhat more important than comprehensiveness and this report should not be regarded as reflecting either the state-of-the-art in forest mensuration or the final form of the vegetation description to be incorporated in the WIND data base.

Emphasis has been placed on foliage surface area insofar as this parameter occurs in a number of the numerical models proposed for application on the WIND data base.

The literature has been surveyed for relevant data on incense cedar by Dennis Galvin with Pacific Southwest Forest and Range Experiment Station. Review and comments have been received from Robert Laacke and LeRoy Dolph with the same organization, and from Boyd Hutchison, with the Atmospheric Turbulence and Diffusion Laboratory, NOAA.

The forest site of the WIND study was established with the cooperation of Diamond Land Corporation. Description of its location and the studies being conducted there are included in the WIND documents:

Operations Plan—DOD, U.S. Army, USDA Forest Service—Cooperative Field Study; Program WIND (J. E. Butterfield and M. A. Alliman), 1985.

Test Plan—USDA Forest Service, DOD, U.S. Army Cooperative Field Study; (R. Ekblad, ed.), 1985.

METHODS

Canopy structure measurements at the Program WIND forest site must be nondestructive under the terms of the lease. Even if this were not the case,

actual felling and dissection of such large trees in the numbers required for statistically valid direct measurement would be far beyond available resources. Accordingly, "direct" or photographic methods must be used. "Direct" in this case means the "regression of structural characteristics on gross plant features".[1] From a practical point of view, the only gross plant features available are those which can be measured from the ground or from aerial photographs. The "diameter inside the bark at the base of the live crown," for example,[2] is virtually inaccessible.

Similarly, the only photographic measurements which can be made over appreciable areas of the canopy are either from the stand floor or well overhead from an aircraft.

The measurements presented in this memo consist of:

1. the tree stem diameter at a height of about 1.5 m (d.b.h.);
2. the elevation angles of the crown top, the lowest live branch, and the tree base from a position at a measured distance from the base using an Abney level;
3. species; and
4. vertical photographs of the canopy.

These measurements were made on two square plots with an area of 522 m^2 each, including the edge tower site (Plot 1) and the central tower site (Plot 2). Canopy photographs were taken at the points trisecting the diagonals of the plot.

While measurements (1) and (3) were feasible for all trees in both plots, visibility was too poor near Plot 2 to execute measurement (2) on more than a small fraction of the trees.

RESULTS

A complete census of the trees in the two plots is given in tables 1a, and 1b, in terms of d.b.h. and an index specifying the apparent species. Dead trees (about four in all) were omitted. About the same number of stems were found on Plot 1 (80) as on Plot 2 (73). A major difference is the presence of oak on Plot 2 and more incense cedar than on Plot 1. D.b.h. averaged about 20.5 cm on Plot 2 with a standard deviation of 12 cm. The values for Plot 1 are 33.7 cm and 14 cm.

The results of measurement (2) are shown in tables 2a and 2b together with the average heights 13.3 m and 11.2 m for Plots 1 and 2, and the standard deviations 3.6 and 2.9 m, respectively.

The photographs are reproduced as fig. 1a through 1d. Apparent canopy cover for the areas within 30 degrees of the zenith was estimated using a standard template method at 47 percent for Plot 1 and 53 percent for Plot 2.

The floor was relatively unvegetated for both plots although there was heavy brush cover in nearby clearings (fig. 1e and 1f). There were appreciable dead fall and slash.

FOLIAGE ESTIMATES

Most of the regressions relating crown biomass components to d.b.h. are of the form:

$$W = A\ (\text{d.b.h.})^{b} \qquad (1)$$

W is the weight of the component, e.g., foliage, branches, etc. For this report, W is the ovendry weight of the foliage on the tree. The units of relation (1) are often mixed; d.b.h. being in inches and W in kilograms.

The constants A and b are presumably species dependent and, unfortunately, also reflect site quality and stem density.

For ponderosa pine three sets of A and b appear in literature:

$$b = 1.15 \quad A = .346 \qquad (2a)^3$$

$$b = 1.67 \quad A = .186$$

$$b = 1.88 \quad A = .132 \qquad (2b)^4$$

$$b = 1.99 \quad A = .170 \qquad (2c)^5$$

The second, third, and fourth results are based on samples of 20 trees or more and are essentially in agreement. The third was used to estimate the pine contribution to the LAI at the experimental site together with the relation:

$$F = 5.65 + 5500\ W \qquad (3)$$

where F is the total foliage area in square cm.[4]

The oak contribution was estimated from the regressions for black oak due to Rothacher et al.[6] with

$$F = 0.28\ (\text{d.b.h.})^{1.86} \qquad (4)$$

using the late growing season leaf area.

A major difficulty occurs with the contribution of the incense cedar. No relations of the form (1) have been developed for this species. The only available measurements appear to have been made by Storey and Fons[2] and these are reported in terms of the "diameter at the base of the live crown." Only two trees were dissected; moreover, no relation between F and W seems to have been established for incense cedar.

For a preliminary estimate, the cedar has been treated as though identical to the pine and, to the extent that most of the cedars were small, the error may be acceptable. On this basis, the LAI for Plot 1 (only one side per leaf) is 8.4 and for Plot 2 is about 4.0. This result contradicts the canopy cover measurements and further replication of the latter would be needed to see if this result is due to sampling error.

For shade intolerant species, the distribution of foliage with height on a particular tree can be approximated reasonably well by a truncated Gaussian curve[7] with the center at midcrown and with a standard deviation about one-fifth of the live crown length. The distribution is truncated at $\pm$ 1.25 standard deviation. The quality of the approximation varies with site and species, but the errors for a particular stand seem to be unbiased. This assumption was used to construct an estimated vertical distribution of foliage for the two plots as shown in fig. 2 below. The plotted points are the fraction of the estimated LAI falling within the 50 cm layer centered at a particular height. The tabulated values are listed in table 3a and 3b. These curves were constructed by distributing the estimated foliage area of each tree in tables 2a and 2b between height intervals in proportion to the fraction found in the truncated Gaussian distribution calculated from the live crown length and tree height. This composite distribution was then normalized by the total

LAI contribution for all of the trees in the table. The heights above 85 percent of the LAI are indicated on the figure as Z85. No confidence intervals were calculated, but it is obvious that the higher percentile estimates would have extreme sampling instability. Tables 3a and 3b also list the fraction of the total LAI lying below a particular level (ACC).

COMMENTS AND SUGGESTIONS

If the LAI estimates can be taken at face value the stand at the forest site is somewhat sparse compared to the Douglas-fir stand used in a somewhat comparable study which had LAI ranging from 20.5 to 6.13 for about six comparable plots.[8]

While the difference in LAI between the two plots is probably real, the difference in the vertical profiles and height statistics may likely reflect the small sample of heights taken on Plot 2. The relative irregularity of the latter profile would be consistent with this explanation.

It is obvious that more plot measurements will be needed with a reasonable number in the clearings near the transect towers. Such sampling would be most effective if coordinated with low altitude aerial stereophotography. There is a good possibility that structural data for incense cedar can be found in a closer examination of the literature.

Table 1a—Total census of stems (d.b.h.—species), Plot 1

26.00	2	14.00	2	31.00	1
8.00	1	18.00	2	11.00	2
8.00	2	8.00	2	16.00	2
20.00	1	9.00	1	12.00	1
16.00	2	28.00	1	28.00	1
40.00	1	33.00	2	24.00	2
27.00	1	28.00	2	23.00	2
16.00	1	35.00	2	45.00	1
37.00	1	25.00	1	35.00	2
28.00	1	12.00	1	13.00	2
18.00	2	12.00	2	11.00	1
11.00	2	10.00	2	10.00	2
11.00	1	10.00	1	6.00	1
15.00	2	28.00	2	39.00	2
26.00	2	11.00	2	15.00	2
16.00	2	42.00	2	38.00	2
16.00	2	49.00	1	29.00	2
12.00	2	15.00	2	26.00	1
25.00	2	13.00	2	12.00	1
12.00	1	8.00	1	11.00	2
9.00	1	21.00	2	9.00	2
13.00	2	10.00	2	9.00	2
13.00	2	9.00	2	6.00	2
65.00	3	42.00	1	35.00	2
24.00	2	0.00	0	0.00	0

Species: pine = 1, cedar = 2, oak = 3
Number of live stems = 80
Average d.b.h. = 33.7 cm
Standard deviation d.b.h. = 13.5 cm

Table 1b—Total census of stems (d.b.h.-species), Plot 2

28.00	1	29.00	1	27.00	1
51.00	1	38.00	1	65.00	1
23.00	2	23.00	2	28.00	2
10.00	2	13.00	2	9.00	2
48.00	1	24.00	2	52.00	1
26.00	2	28.00	1	22.00	1
51.00	1	17.00	2	24.00	1
27.00	1	32.00	1	24.00	1
26.00	1	29.00	1	38.00	1
50.00	1	19.00	2	20.00	2
30.00	1	40.00	2	30.00	3
30.00	3	30.00	3	34.00	1
37.50	1	59.90	1	26.00	2
22.60	2	41.50	1	58.20	1
41.50	1	58.20	1	56.60	1
53.40	1	28.70	1	27.50	2
48.70	1	32.20	1	40.30	1
32.30	1	24.50	2	37.30	1
35.60	1	24.20	1	29.10	1
61.90	1	32.40	1	32.30	1
41.40	1	32.20	2	53.20	1
44.40	1	26.80	1	28.80	1
28.10	1	35.80	1	22.20	1
49.40	1	45.50	1	42.50	1
15.30	1	13.20	2	9.70	1
11.80	1	11.80	2	44.00	1
51.00	1	50.00	1	0.00	0

Species: pine = 1, cedar = 2, oak = 3
Number of live stems = 73
Average d.b.h. = 20.5 cm
Standard deviation d.b.h. = 12.1 cm

Table 2a—Detailed sample survey of Plot 1

Height (cm)	HLC (cm)	D.B.H. (cm)	Species
1419.8	641.2	34.0	1
1179.7	502.0	37.5	1
1386.0	630.0	59.9	1
483.6	312.0	26.0	2
662.4	432.0	22.6	2
1178.0	589.0	41.5	1
1670.4	835.2	58.2	1
1729.2	628.8	56.6	1
1475.6	666.4	53.4	1
1462.5	975.0	28.7	1
800.3	60.4	27.5	2
1568.0	672.0	48.7	1
1095.0	438.0	32.2	1
1314.0	613.2	40.3	1
1016.0	609.6	32.3	1
601.6	345.6	24.5	2
1206.0	603.0	37.3	1
1267.2	614.4	35.6	1
1168.0	528.0	24.2	1
1254.4	806.4	29.1	1
1849.0	774.0	61.9	1
1488.5	687.0	32.4	1
1377.6	1049.6	32.3	1
1635.6	1009.2	41.4	1
783.9	180.9	32.2	2
1722.0	1218.0	53.2	1
1610.4	640.5	44.4	1
1098.0	420.9	26.8	1
1352.8	676.4	28.1	1
2106.0	999.0	35.8	1
873.3	664.2	22.2	1
1764.0	1092.0	49.4	1
1770.8	1071.8	45.5	1
1427.8	847.0	42.5	1
1064.0	425.6	36.3	2
1491.0	525.0	50.0	1
1608.0	964.8	44.0	1
1782.1	702.8	51.0	1
1786.2	824.4	50.0	1
1530.0	1.5	12.2	1
1320.0	3.1	9.2	2

Table 2a—(continued)

Height (cm)	HLC (cm)	D.B.H. (cm)	Species
970.0	2.4	4.9	1
1180.0	2.4	12.2	1
1180.0	3.1	13.7	2

Species: pine = 1, cedar = 2, oak = 3
Average height = 13.3 m
Standard deviation of height = 3.56 m

Table 2b—Detailed sample survey of Plot 2

Height (cm)	HLC (cm)	D.B.H. (cm)	Species
601.4	48.5	16.6	1
800.3	135.9	36.8	2
1246.2	341.7	41.8	2
1063.8	354.6	30.9	1
1009.2	400.2	29.0	1
1071.2	515.0	29.3	1
1122.1	572.5	42.7	2
1562.4	753.3	50.0	1
1590.3	892.8	43.0	1
836.4	295.2	33.1	2
1122.0	627.0	20.8	1
1465.0	586.0	41.4	1

Species: pine = 1, cedar = 2, oak = 3
Average height = 11.2 m
Standard deviation of height = 2.92 m

Table 3a—Estimated vertical distribution of fractional leaf area, Plot 1

Height (cm)	Derivative	ACC
50.00	0.000	0.000
100.00	0.000	0.000
150.00	0.000	0.000
200.00	0.000	0.000
250.00	0.001	0.001
300.00	0.002	0.003
350.00	0.005	0.008
400.00	0.011	0.019
450.00	0.013	0.032
500.00	0.011	0.043
550.00	0.011	0.054
600.00	0.011	0.065
650.00	0.013	0.078
700.00	0.020	0.098
750.00	0.034	0.132
800.00	0.045	0.177
850.00	0.052	0.229
900.00	0.057	0.286
950.00	0.061	0.347
1000.00	0.064	0.411
1050.00	0.063	0.474
1100.00	0.061	0.535
1150.00	0.059	0.594
1200.00	0.060	0.654
1250.00	0.060	0.714
1300.00	0.057	0.771
1350.00	0.055	0.826
1400.00	0.051	0.877
1450.00	0.044	0.921
1500.00	0.034	0.955
1550.00	0.021	0.976
1600.00	0.011	0.987
1650.00	0.004	0.991
1700.00	0.002	0.993
1750.00	0.001	0.993
1800.00	0.000	0.994
1850.00	0.000	1.000

Table 3b—Estimated vertical distribution of fractional leaf area, Plot 2

Height (cm)	Derivative	ACC
50.00	0.000	0.000
100.00	0.000	0.000
150.00	0.000	0.000
200.00	0.000	0.000
250.00	0.001	0.001
300.00	0.002	0.003
350.00	0.004	0.006
400.00	0.007	0.013
450.00	0.011	0.024
500.00	0.018	0.042
550.00	0.027	0.069
600.00	0.036	0.105
650.00	0.039	0.143
700.00	0.036	0.180
750.00	0.035	0.215
800.00	0.042	0.257
850.00	0.054	0.310
900.00	0.072	0.382
950.00	0.086	0.468
1000.00	0.089	0.557
1050.00	0.075	0.632
1100.00	0.047	0.679
1150.00	0.035	0.714
1200.00	0.042	0.756
1250.00	0.049	0.805
1300.00	0.051	0.856
1350.00	0.045	0.901
1400.00	0.032	0.933
1450.00	0.019	0.952
1500.00	0.009	0.962
1550.00	0.004	0.965
1600.00	0.000	1.000

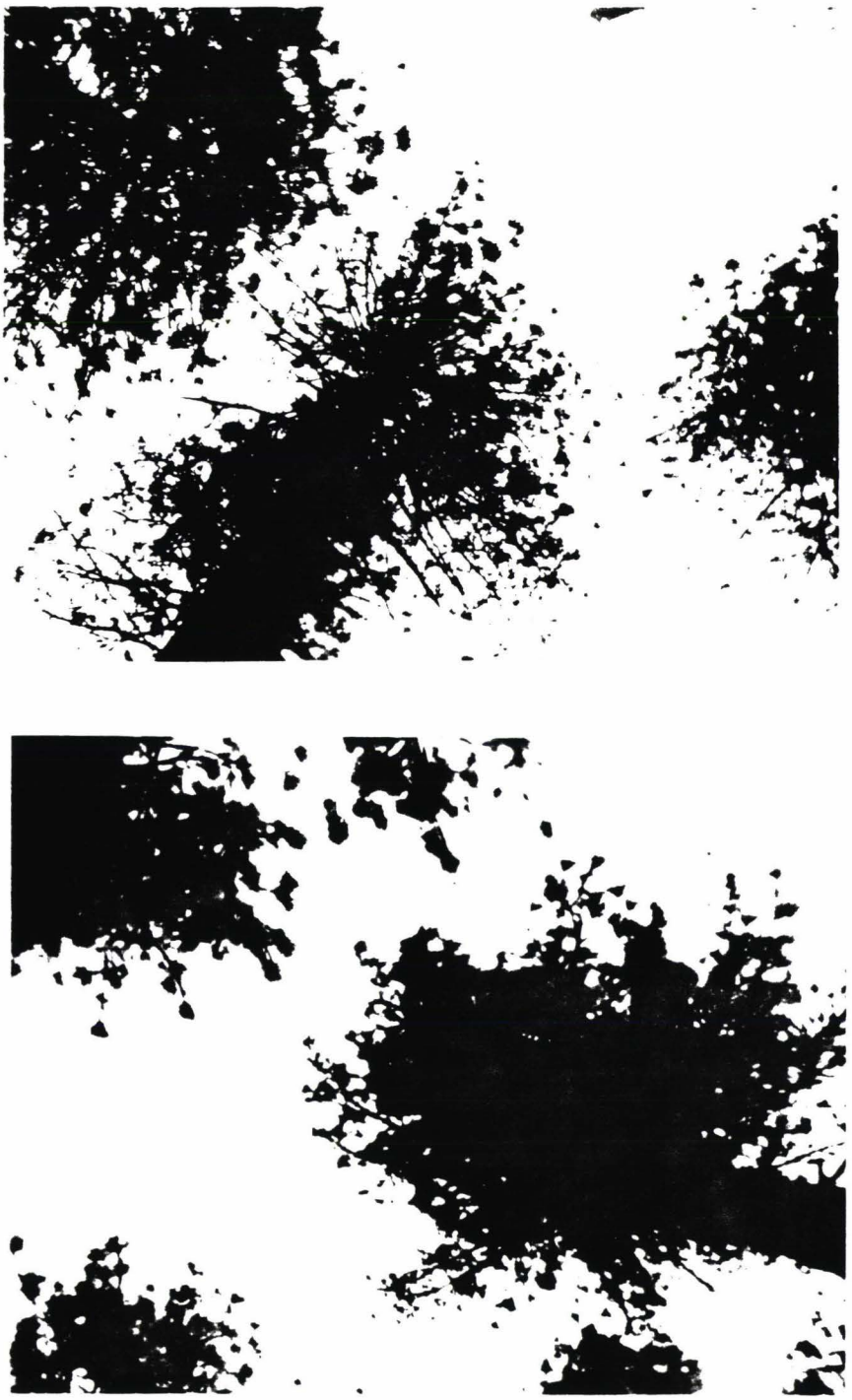

Figure 1a—Vertical canopy photographs (maximum dimension = 45 degrees), Plot 1.

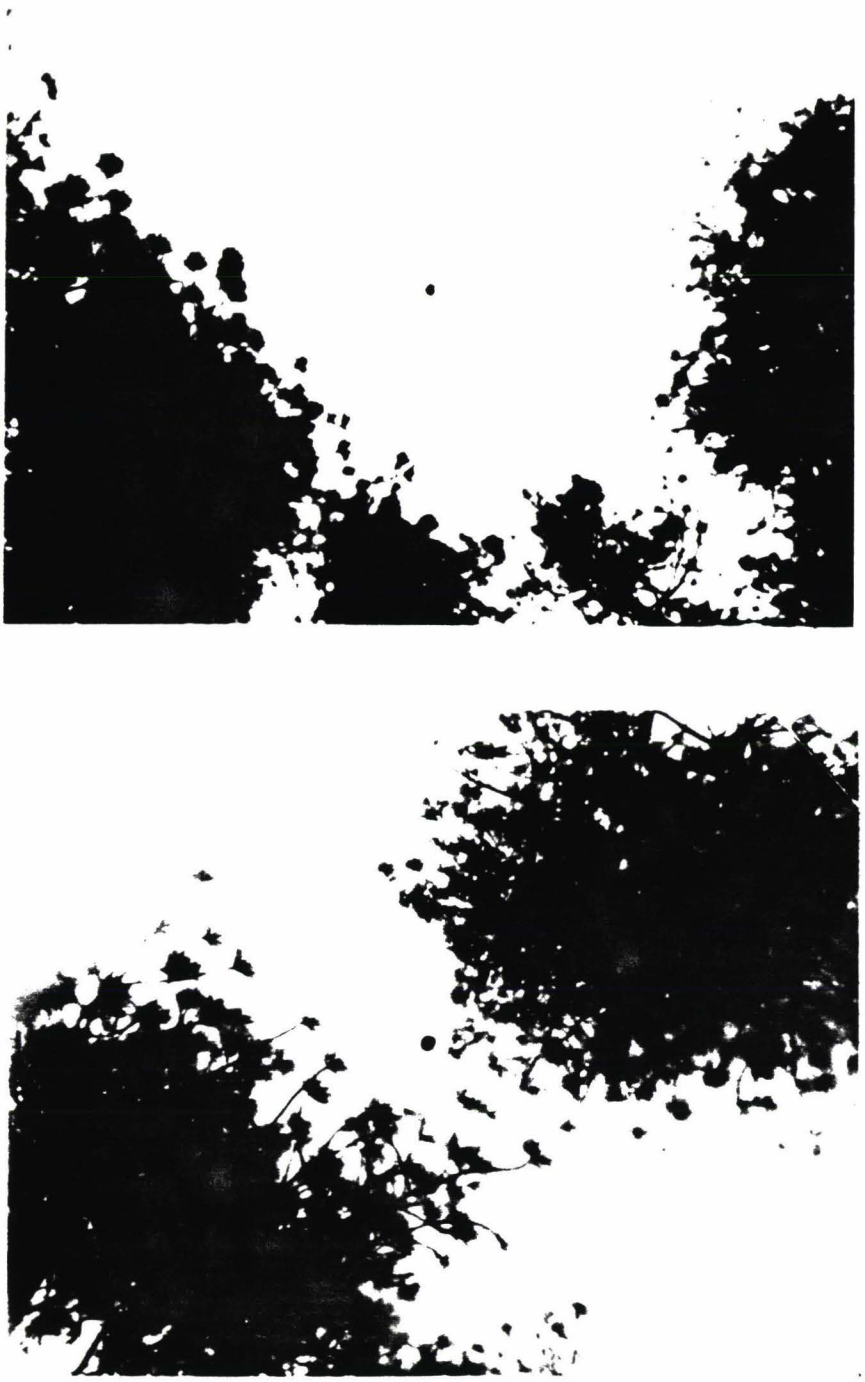

Figure 1b—Vertical canopy photographs (maximum dimensions = 45 degrees), Plot 1.

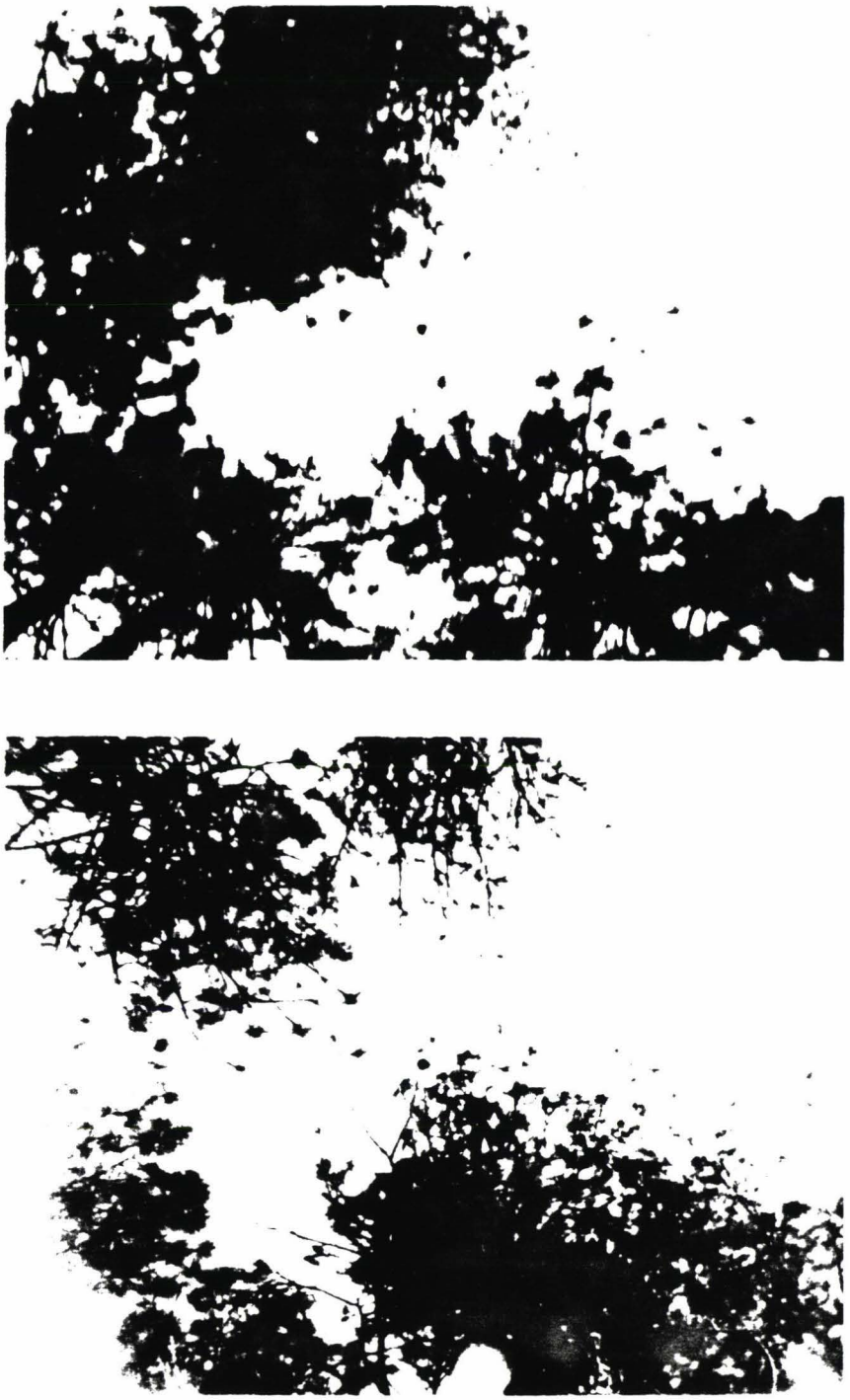

Figure 1c—Vertical canopy photograph (maximum dimension = 45 degrees), Plot 2.

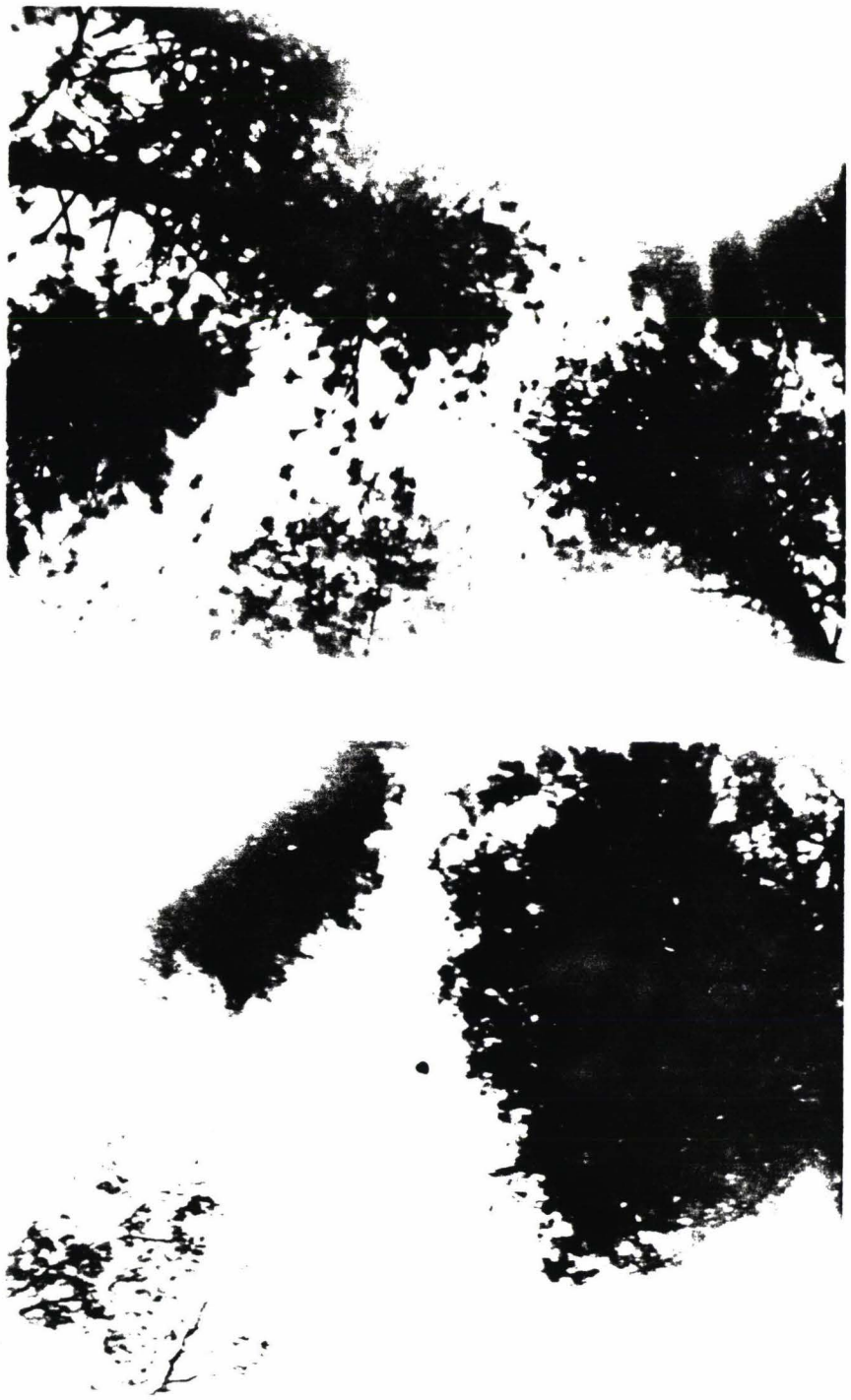

Figure 1d—Vertical canopy photograph (maximum dimension - 45 degrees), Plot 2.

Figure 1e—Stand floor, Plot 1.

Figure 1f—Stand floor, Plot 2.

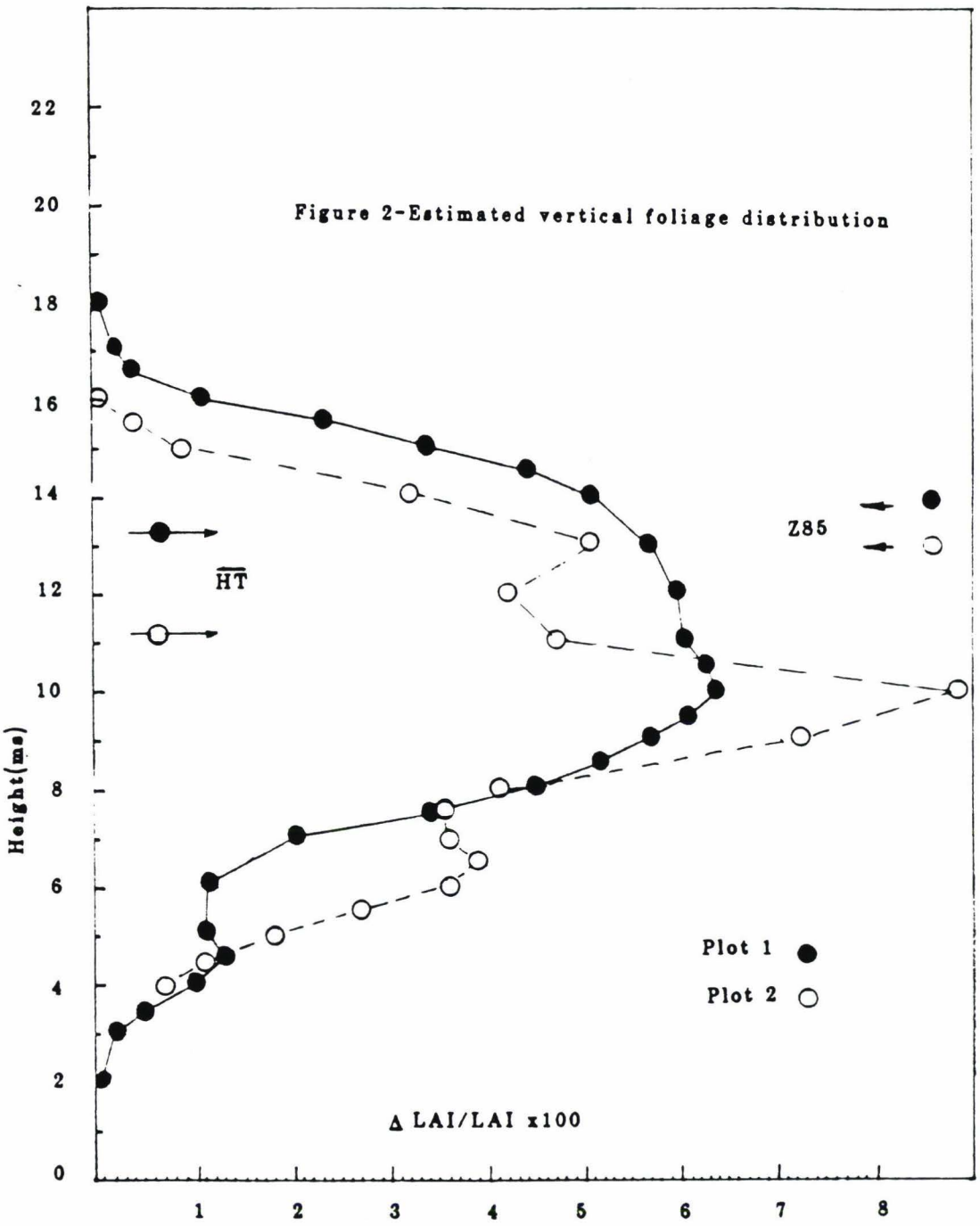
Figure 2-Estimated vertical foliage distribution
Height(ms)
22
20
18
16
14
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8
HT
Z85
Plot 1
Plot 2
Δ LAI/LAI x100

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